

TECHNOLOGY FOR SPACE STATION EVOLUTION
- A WORKSHOP

EXTRAVEHICULAR ACTIVITY SYSTEM

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TECHNOLOGY FOR SPACE STATION EVOLUTION - A WORKSHOP

Presentation Outline

EVAS PROGRAM STATUS

DEFINE EVAS BASELINE

BASELINE FUNCTIONAL REQUIREMENTS

DEFINE EVOLUTIONARY EVAS

EVOLUTIONARY EVAS FUNCTIONAL REQUIREMENTS

TECHNOLOGY STATUS

EVAS PROGRAM STATUS

PROGRAM HISTORY

Phase A & B studies supported the need for Routine EVA to:

Assemble, Maintain, and Service
Space Station Freedom
Satellites
Spacecraft
Experiments

As a result requirements emphasized:

Utilization constrained by human, not hardware
Life cycle costs
Reduced crew overhead

Configuration selection studies were done during Phase B that:

Looked at 10 options of EMU including:
Modified and Unmodified NSTS EMUs
New Space Station Freedom EMUs
Non-Anthropomorphic Systems

Looked at Vehicle options including:
2 Pressure Station
Walk Around Prebreather

Treated demand parametrically over the range of 1 to 5 per week

Resulting selected configuration was a new design SSF EMU that used regenerative technologies and was automatically serviceable.

EVAS PROGRAM STATUS

PROGRAM HISTORY (continued)

October 1986 Critical Evaluation Task Force (CETF)

Reduced EVA tasks by reducing Space Station Scope and moving components inside

Set Planned EVA frequency at 1 EVA/Week

Baselined Space Station Based EVA at PMC

Phase 1 Scale Down

Eliminated some requirements for early user EVA

Stretched out the schedule

Tanner Technical Audit

Eliminated Non-venting requirement based on user needs

Scrub 89

Eliminated Routine EVA requirement

Directed use of NSTS EMU to provide Contingency EVA when the Orbiter is present

Eliminated 2nd Air Lock

EVAS BASELINE DEFINATION

The EVAS consists of hardware, applications software, and the EVAS common interfaces with other systems and elements which provide the capability for the space station crew to perform contingency tasks in an unpressurized environment. All other EVA will be performed during orbiter resupply periods. The EVAS will support maintenance, repair, and inspection of space station systems and elements. The EVAS consists of the following items:

- 1) Space station based NSTS Extravehicular Mobility Unit (EMU) that provides an anthropomorphic pressure suit, portable life support, and EVA crew communications, and physiological monitoring.
- 2) EVAS Service and Performance Checkout Unit (SPCU) provides for the resupplying of EVAS equipment between EVAS. The SPCU includes umbilicals which interface EVAS equipment to the servicing equipment to support EVA operations and intravehicular operations during EMU donning and transition to vacuum. The SPCU provides performance checkout and instrumentation verification of serviceable EVAS equipment.
- 3) Airlock chamber depress/repress equipment and controls
- 4) EVA hyperbaric life support and chamber pressurization equipment and controls
- 5) EVA translation and mobility aids (including those required to Space Station Manned Base [SSMB] assembly
- 6)
- 7) EVA external lighting (including docking and proximity operations lighting)
- 8) EVA support equipment and generic tools including crew positioning devices required to support SSMB assembly
- 9) EVA external equipment storage (including lockers and other equipment holding fixtures)
- 10) EV contamination detection and decontamination unit
- 11)

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EXTRAVEHICULAR ACTIVITY SYSTEM - BASELINE DEFINATION

The EVAS provides for contingency tasks in an unpressurized environment and consists of:

- 1) Space Station Based NSTS Extravehicular Mobility Unit (EMU)
Anthropomorphic Pressure Suit
Communications
Portable Life Support,
Physiological Monitoring
- 2) EVAS Service and Performance Checkout Unit (SPCU)
Reservicing of EVAS equipment
Umbilicals
Performance Checkout Of
Servicable EVAS Hardware
- 3) A/L Depress/Repress
- 4) Hyperbaric Life Support
- 5) Translation and Mobility aids
- 6)
- 7) EVA External Lighting
- 8) EVA Support Equipment and Tools
- 9) EVA Storage
- 10) EV Contamination Detection and
Decontamination

11)

The System Definition is Controlled by "Architectural Control Document
Extravehicular Activity System" SSP 30256

EVAS BASELINE FUNCTIONS

EVA Mobility is the ability of the EVA crewperson to move in a zero-gravity, vacuum environment as required to accomplish useful tasks.

EVA dexterity is the ability of the EVA crewmember to precisely perform tasks involving the hands without the use of excessive force, the generation of undue fatigue, or the infliction of injury to the hands.

EVA life support is the maintenance of a pressurized, breathable, thermally comfortable atmosphere and well as protection from the space environment.

EVAS service and performance checkout is the activity required to prepare and maintain in a ready state EVAS equipment for EVA. This includes

- reservicing EVA expendables**
- verification of go/no-go status of EVA equipment**
- Intravehicular support for don/doff and checkout**

monitoring of expendables prep for use

powered EVA equipment is the electrical recharge of portable, powered equipment batteries

Communications provides the EVA crew person the proper information in order to perform the EVA tasks. Communications for the EVA crew consists of voice communication to and from the Space Station, data communications to the space station and voice communication between EVA Crew members. The EVA Crew will communicate with the ground via the Space Station.

EVA Crew Tracking Is the maintenance of a constant knowledge of the position of the EVA crewperson with sufficient accuracy to maintain safety of the crewperson and protection of space station external systems.

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EXTRAVEHICULAR ACTIVITY SYSTEM - BASELINE FUNCTIONS

EVA Mobility - moving in a zero-gravity, vacuum environment

EVA Dexterity - precisely performing tasks involving the hands without excessive force, undue fatigue, or injury to the hands.

EVA life support - maintenance of a pressurized, breathable, thermally comfortable atmosphere & protection from the space environment.

EVAS Service & Performance Checkout - prepare and maintain ready EVAS equipment while requiring minimum IV time. This includes:
Reservicing Expendables Monitoring of Expendables
Go/No-Go Status Routine Prep for Use
Intravehicular Support

Equipment Recharge - recharge of portable, powered equipment batteries.

Communications - providing proper information to perform the EVA tasks. It consists of:

Voice to and from the SSF Data to the Space Station
Voice Between EVA Crew

EVA Crew Tracking - maintaining constant knowledge of the position of the EVA crewperson to maintain safety and protection of space station external systems.

EVAS BASELINE FUNCTIONS

EVAS Information Management is those activities required to service, detect failures, and maintain histories for the EVAS hardware, to store and manipulate EVAS user data and C&W information.

EVA Maintenance/Service is the planned and unplanned manual maintenance and servicing required to keep all hardware items of the EVAS functional and available for use. NSTS EMUs have limited on-orbit maintenance capability making it necessary to replace at the NSTS EMU end item level.

EVA equipment external storage is the activity to provide EVAS hardware which remains external the necessary berthing, enclosure/protection, and/or restraints to allow proper storage. The storage devices allow EVA crew access to the stored items. Provision for temporary storage at a high use worksite is made to minimize crew overhead.

EVA Decontamination and Detection is the detection and removal of any hazardous contamination which the EVA crewperson encounters while performing EVA to a safe level before the crewperson reenters the airlock to avoid contamination of the Internal Space Station.

Airlock Depress/Repress Control is the dynamic control of the depress/repress cycle. It includes the ability to stop the cycle and to control rate. Manual initiation from inside or outside the airlock or by the IVA crew from inside the adjacent resource node is provided.

EVA Crew and Equipment Transstation is the activity to allow the EVA crewperson access to all parts of the Space Station, Platform, and Payloads while attached to the Space Station.

EVA External Lighting supplies adequate lighting during the night cycle or into shadowed areas to allow visual access by the EVA crewperson and visual tracking of the EVA crew using closed circuit TV. The function includes both fixed and movable lights and the ability to easily switch lights. EVA lights also support docking, berthing, and proximity operations.

TECHNOLOGY FOR SPACE STATION EVOLUTION - A WORKSHOP

EXTRAVEHICULAR ACTIVITY SYSTEM - BASELINE FUNCTION'S

EVAS Information Management - activities to service, detect failures, and maintain histories for the EVAS hardware, to store and manipulate EVAS user data and C&W information.

EVA Maintenance/Service - Planned & Unplanned manual maintenance and servicing of the EVAS NSTS EMUs have limited on-orbit maintenance capability requiring replacement at the NSTS EMU end item level

EVA Crew and Equipment Retrieval - retrieving an incapacitated EVA crewmember who is detached from the Space Station. Crew retrieval capability used for detached equipment retrieval

EVA Equipment External Stowage - provides the necessary berthing, enclosure/protection, and/or restraints to allow proper storage of External EVAS equipment.

EVA Decontamination and Detection - Detection and Removal Hazardous Contamination to a Safe Level Before Reentry to the Airlock

Airlock Depress/Repress Control - Dynamic Control of the Depress/Repress Cycle.

EVA Crew and Equipment Translation - EVA crewperson access to all parts of the Space Station, Platform, and Payloads while attached to the Space Station.

EVA External Lighting - Adequate lighting during the night cycle

EVAS BASELINE FUNCTIONS

EVA Restraint Is all activities to properly, safely, and easily restrain both the EVA crewperson and all hardware items which are moved during EVA.

Hyperbaric operations consists of all unique activities required to provide a hyperbaric chamber facility for medical treatment / procedures requiring atmospheric pressures higher than nominal module pressure. It includes life support, pressurization/depressurization, thermal control, and lighting. Life Support includes breathing gas mixture control and fire detection and suppression

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EXTRAVEHICULAR ACTIVITY SYSTEM - BASELINE FUNCTIONS

EVA Restraint - Safely, and easily restrain both the EVA crewperson and all hardware items which are moved during EVA.

Hyperbaric Operations - Providing a hyperbaric chamber facility for medical treatment/procedures. Includes life support, pressurization/depressurization, thermal control, and lighting.

EVAS EVOLUTION DEFINATION

The EVAS consists of hardware, applications software, and the EVAS common interfaces with other systems and elements which provide the capability for the space station crew to perform routine tasks in an unpressurized environment. The EVAS will support installation/assembly, maintenance, repair, inspection, and servicing of space station systems and user items.

The EVAS consists of the following items:

- 1) Space Station Extravehicular Mobility Unit (EMU) that provides an anthropomorphic pressure suit, portable life support, and EVA crew communications, physiological monitoring, and EMU mounted lights.
- 2) EVAS Service and Performance Checkout Subsystem (SPCS) which provides for the regeneration and servicing of EVAS equipment between EVAS, automatic performance checkout and instrumentation verification of the EVAS components (including Built In Test Equipment [BITE/self testing), umbilicals which Interface EVAS equipment to the servicing equipment for both normal and contingency EVA operations, and intravehicular support during EMU donning and transition to vacuum.
- 3) Airlock chamber depress/repress equipment and controls
- 4) EVA hyperbaric life support and chamber pressurization equipment and controls
- 5) EVA translation and mobility aids (including those required to Space Station Manned Base [SSMB] assembly
- 6) EVA crew and equipment retrieval subsystems and retrieval subsystems servicing
- 7) EVA external lighting (including docking and proximity operations lighting)
- 8) EVA support equipment and generic tools including crew positioning devices required to support SSMB assembly
- 9) EVA external equipment storage (including lockers and other equipment holding fixtures)
- 10) EV contamination detection and decontamination unit
- 11) Extravehicular Excursion Unit (EEU) seat

FOR SPACE STATION EVOLUTION - A WORKSHOP

EXTRAVEHICULAR ACTIVITY SYSTEM - EVOLUTION DEFINITION

The EVAS provides for routine tasks in an unpressurized environment and consists of

- | | |
|---|---|
| 1) Extravehicular Mobility Unit (EMU)
Anthropomorphic Pressure Suit
Communications
EMU Mounted Lights. | Portable Life Support,
Physiological Monitoring |
| 2) EVAS Service and Performance Checkout Subsystem (SPCS)
Reservicing of EVAS equipment
Umbilicals | Automatic Performance
Checkout |
| 3) A/L Depress/Repress | 4) Hyperbaric Life Support |
| 5) Translation and Mobility aids | 6) Crew and Equipment Retrieval |
| 7) EVA External Lighting | 8) EVA Support Equipment and Tools |
| 9) EVA Storage | 10) EV Contamination Detection and
Decontamination |
| 11) EEU Seal | |

The System Definition is Controlled by "Architectural Control Document
Extravehicular Activity System" SSP 30256

EVAS EVOLUTION FUNCTIONS

EVA Mobility is the ability of the EVA crewperson to move in a zero-gravity, vacuum environment as required to accomplish useful tasks.

EVA dexterity is the ability of the EVA crewmember to precisely perform tasks involving the hands without the use of excessive force, the generation of undue fatigue, or the infliction of injury to the hands.

EVA life support is the maintenance of a pressurized, breathable, thermally comfortable atmosphere as well as protection from the space environment.

EVAS service and performance checkout is the activity required to prepare and maintain in a ready state EVAS equipment for EVA while requiring a minimum of time or attention from IV crewmembers. This includes:

- Reservicing of recoverable EVA expendables
- Continuous monitoring of expendables
- go/no-go status upon request and prior to use
- Intravehicular support for don/doff and checkout
- reservicing of non-recoverable EVA expendables
- automated performance checkout
- routine prep for use
- reverification following ORU replacement

Powered EVA equipment is the electrical recharge of portable, powered equipment batteries

Communications provides the EVA crew person the proper information in order to perform the EVA tasks. It consists of voice and data to and from the Space Station, video to the Space Station, text and graphics transfer from the Space Station to the EVA crewperson, and voice communication between EVA Crew members. The EVA Crew will communicate with the STS Orbiter via the Space Station.

TECHNOLOGY FOR SPACE STATION EVOLUTION - A WORKSHOP

EXTRAVEHICULAR ACTIVITY SYSTEM - EVOLUTION FUNCTIONS

EVA Mobility - moving in a zero-gravity, vacuum environment

EVA Dexterity - precisely performing tasks involving the hands without excessive force, undue fatigue, or injury to the hands.

EVA life support - maintenance of a pressurized, breathable, thermally comfortable atmosphere & protection from the space environment.

EVA's Service & Performance Checkout - prepare and maintain ready EVAS equipment while requiring minimum IV time. This includes:

- Regenerating Recoverable Expendables
- Reservicing Expendables
- Continuous Monitoring of Expendables
- Automated Performance
- Go/No-Go Status
- Checkout
- Routine Prep for Use
- Reverification After
- Intravehicular Support
- Maintenance

Equipment Recharge - recharge of portable, powered equipment batteries.

Communications - providing proper information to perform the EVA tasks. It consists of:

Voice and Data to and from the SSF
Text & Graphics from the SSF to EVA

Video to the Space Station
Voice Between EVA Crew

EVAS EVOLUTION FUNCTIONS

EVA Crew Tracking is the maintenance of a constant knowledge of the position of the EVA crewperson with sufficient accuracy to maintain safety of the crewperson and protection of space station external systems.

EVAS Information Management is those activities required to operate, service, detect failures in, and maintain performance histories for the EVAS hardware, to store and manipulate user data and C&W information, and to allow "hands-free" EVA access by the EVA crewperson, and to provide appropriate command/response and information services to the OMS.

EVA Maintenance/Service is the planned and unplanned manual maintenance and servicing required to keep all hardware items of the EVAS functional and available for use. This includes periodic cleaning, lubrication, and other preventive maintenance of the EMU, as well as cleaning the SSA of biological contaminants.

EVA Crew and Equipment Retrieval is the activities required to retrieve an incapacitated EVA crewmember who has become detached from the Space Station. An awaiting EVA crewmember will assist with ingress of the rescued person. This capability accommodates separation from any point on the Space Station and provides acquisition and return to the A/L within the EMU expendables reserve time. This function shall not additionally jeopardize the safety of another crewmember. Capability for crew retrieval shall be used for detached equipment retrieval when appropriate. The function includes the EVA activities required to release a trapped or pinned EVA crewperson.

EVA equipment external storage is the activity to provide EVAS hardware which remains external the necessary berthing, enclosure/protection, and/or restraints to allow proper storage. The storage devices allow EVA crew access to the stored items. Provision for temporary storage at a high use worksite is made to minimize crew overhead.

EVA Decontamination and Detection is the detection and removal of any hazardous contamination which the EVA crewperson encounters while performing EVA to a safe level before the crewperson reenters the airlock to avoid contamination of the Internal Space Station.

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EXTRAVEHICULAR ACTIVITY SYSTEM - EVOLUTION **FUNCTIONS**

EVA Crew Tracking - maintaining constant knowledge of the position of the EVA crewperson to maintain safety and protection of space station external systems.

EVAS Information Management - activities to operate, service, detect failures in, and maintain performance histories for the EVAS hardware. To store and manipulate user data and C&W information, and to allow "hands-free" EVA access by the EVA crewperson, and to provide appropriate EVA command/response and information services to the OMS.

EVA Maintenance/Servicing - Planned & Unplanned manual maintenance and servicing of the EVAS

EVA Crew and Equipment Retrieval - retrieving an incapacitated EVA crewmember who is detached from the Space Station. Crew retrieval capability used for detached equipment retrieval

EVA Equipment External Stowage - provides the necessary berthing, enclosure/protection, and/or restraints to allow proper storage of External EVAS equipment.

EVA Decontamination and Detection - Detection and Removal Hazardous Contamination to a Safe Level Before Reentry to the Airlock

Airlock Depress/Repress Control - Dynamic Control of the Depress/Repress Cycle.

EVAS EVOLUTION FUNCTIONS

EVA Crew and Equipment Translation is the activity to allow the EVA crewperson access to all parts of the Space Station, Platform, and Payloads while attached to the Space Station.

EVA External Lighting supplies adequate lighting during the night cycle or into shadowed areas to allow visual access by the EVA crewperson and visual tracking of the EVA crew using closed circuit TV. The function includes both fixed and movable lights and the ability to easily switch lights. EVA lights also support docking, berthing, and proximity operations.

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EXTRAVEHICULAR ACTIVITY SYSTEM - EVOLUTION FUNCTIONS

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EVA External Lighting - Adequate lighting during the night cycle

EVA Restraint - Safely, and easily restrain both the EVA crewperson and all hardware items which are moved during EVA.

Hyperbaric Operations - Providing a hyperbaric chamber facility for medical treatment/procedures. Includes life support, pressurization/depressurization, thermal control, and lighting.

EVAS TECHNOLOGY STATUS

To be REGENERABLE a SSF funded technology program was in place that investigated:

For Heat Removable

Indirect Ice Pack

Wax / Radiator with
Thermal Electric Heat
Pump

Vapor Compression

Metal Hydride Heat Pump

For CO2 Removal

Amine Bed (2 versions)

Electrochemically Regenerable
Chemical Adsorber

Metal Oxides (2 versions)

For power supply

Flywheels (study only)

Fuel Cell with Hydride H2 Storage

For Oxygen supply

High Pressure Electrolysis (2 versions)

EVAS TECHNOLOGY STATUS

To be AUTOMATICALLY SERVICIABLE a SSF funded technology program was in place that investigated computer automation in support of

Automatic Recharge	Fault Detection and Analysis
Automatic Status Monitoring	Fault Recovery / Repair
Automatic Checkout	Trending Analysis
Calibration	Time in Service Logging
Configuration Control	Inventory Management

To REDUCE CREW OVERHEAD a SSF funded technology program was in place the investigated:

In the Life Support Arena	Heads Up Display (2 versions)
Automatic Cooling Control	
Electronic Oxygen Regulators	
In the 8.3 psi Suit Arena	
Hard Suit Technology (Ames AX 5)	Mixed Hard / Soft Suit Technology (JSC Mk III)
Gloves (Multiple versions)	